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The Impact of Hallux Valgus on Dynamic Balance in Female High School Teachers: A Cross-Sectional Study in Semarapura

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Abstract

Introduction: Hallux valgus is a common foot deformity, particularly in adult women with prolonged standing activities, such as teachers. This condition can affect dynamic balance through biomechanical changes, including impaired plantar pressure distribution and postural control. This study aims to analyze the relationship between hallux valgus and dynamic balance in female high school teachers in Semarapura.

Methods: This observational study employed a cross-sectional design involving 50 female teachers selected through purposive sampling based on inclusion and exclusion criteria. The degree of hallux valgus was measured using a goniometer, while the dynamic balance was assessed using the Y-Balance Test (YBT). Data were analyzed using the chi-square test.

Results: The findings revealed a significant relationship between hallux valgus and dynamic balance ($p < 0.001$). 70.8% of individuals with hallux valgus were categorized as having poor balance, whereas 84.6% of individuals without hallux valgus were classified as having good balance.

Conclusion: Hallux valgus significantly affects dynamic balance in female high school teachers in Semarapura. Proper management of hallux valgus is essential to improve stability and prevent balance impairments.

Keywords: foot deformity, female teachers, hallux valgus, dynamic balance

Introduction

Dynamic balance is crucial in various daily activities, particularly for individuals with physically demanding occupations, such as teachers. Dynamic balance is the body's ability to maintain the center of gravity (COG) over the base of support (BOS) while in motion.[1] Balance is influenced by sensory systems (vestibular, visual, somatosensory, proprioceptive) and internal factors such as age, sex, COG, BOS, body mass index (BMI), and hallux valgus deformity.[2,3] Hallux valgus is a foot deformity characterized by the lateral deviation of the first proximal phalanx and the medial displacement of the first metatarsal, which can alter plantar pressure distribution, weaken foot muscles, and narrow the BOS. This condition increases the risk of dynamic balance impairment, particularly during activities requiring postural stability, such as prolonged standing or walking.[4,5]

Hallux valgus is more prevalent in women (30%) and individuals over 65, although it is also found in younger and adult populations. Genetic factors and the use of non-ergonomic footwear contribute to its development. Female teachers are at a higher risk of developing hallux valgus due to prolonged use of narrow formal shoes. Teaching activities that involve frequent movement, such as walking around the classroom and standing for extended periods, require optimal dynamic balance. Impaired balance due to hallux valgus can affect comfort and teaching effectiveness.[6] A study conducted in Badung in 2019 reported a hallux valgus prevalence of 40%, with the highest proportion observed in female teachers (51.0%), predominantly among those aged 26–35 years (54%).[7] Teachers with hallux valgus risk experiencing dynamic balance impairments that may hinder their activities, such as teaching and moving around the classroom.

Previous studies have reported varying results regarding the relationship between Hallux valgus and dynamic balance. Research by Shima (2021) and Daeli (2020) found a significant association between hallux valgus severity and dynamic balance, whereas Barbee (2020) did not find such a relationship.[8–10] These discrepancies highlight a research gap in understanding the impact of Hallux valgus on dynamic balance, particularly in working-age adults.

Therefore, further studies are needed to explore how this deformity affects dynamic balance in specific populations, such as female teachers. This study uses the Y-Balance Test as the primary assessment tool to analyze the relationship between hallux valgus severity and dynamic balance in female high school teachers in Semarapura. We hypothesize that a significant relationship exists between hallux valgus severity and dynamic balance in this population.

Methods

This study is an analytical observational study with a cross-sectional approach. It was conducted in several senior high schools in Semarapura, Klungkung District, from May to June 2024. The sample was selected using purposive sampling, involving 50 female high school teachers who met the inclusion criteria: aged 25–60 years, normal BMI (18.5–24.9 kg/m²) measured using a scale and stadiometer, able to walk independently, in good health, and willing to participate. The exclusion criteria included a history of fracture surgery, sensory disturbances, and balance disorders such as vertigo. Participants were recruited through coordination with school authorities.

The sample size was calculated using Lemeshow's formula for proportion testing, based on a prevalence of 40% of Hallux valgus in previous studies. With a 10% margin of error and a 95% confidence level, a minimum sample size of 49 participants was determined.[9] The measured variables included the degree of hallux valgus and dynamic balance, while control variables encompassed sex, age, and BMI.

Hallux valgus was defined as a deformity of the first metatarsophalangeal joint, measured using a goniometer and categorized as HV (≥15°) or regular (<15°). Measurements were taken with participants seated, knees at 90°, and feet in a neutral position. The goniometer's center was placed on the first metatarsophalangeal joint, with one arm aligned with the first metatarsal and the other with the proximal phalanx of the hallux. Measurements were repeated three times, and the average value was recorded.[11] Participants were classified as having hallux valgus if one or both feet had an angle of ≥15°.

Dynamic balance was assessed using the Y-Balance Test (YBT), which is widely used for musculoskeletal injury screening and neuromuscular deficits.[12] The YBT has an ICC of 0.79–0.86, indicating high reliability, making it suitable for a healthy population.[13] The test was performed barefoot, with participants standing on a central platform. It involved three reach directions (anterior, posteromedial, and posterolateral), performed three times per leg while keeping hands on the waist. Reach distances were recorded, and a composite score was calculated using a formula normalized to leg length. The test was considered unsuccessful if the participant lost balance or touched the floor with the reaching foot before returning to the starting position.[14] A composite reach distance of ≥81 was classified as balanced, while <81 was categorized as unbalanced.[15]

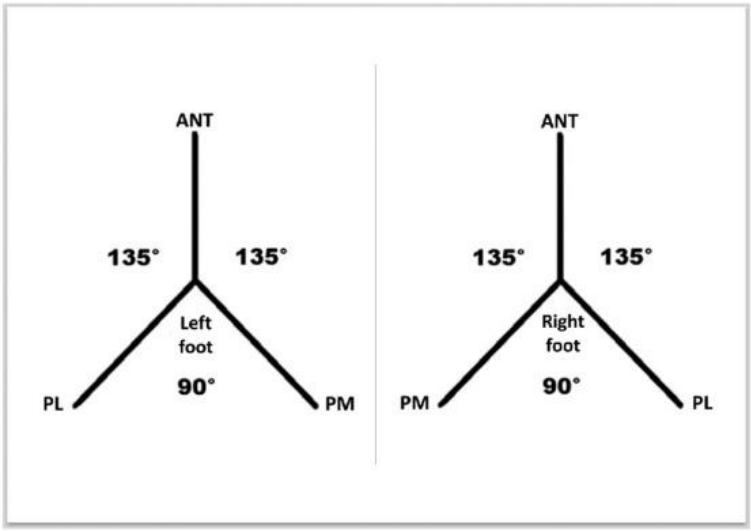

Figure 1. Angles of Reach Directions in the Y-Balance Test

To minimize bias, participant recruitment was conducted systematically through school coordination; the same researcher performed all measurements to ensure consistency, and control variables (age and BMI) were applied to reduce confounding effects on dynamic balance. Data analysis was conducted using SPSS 27.0, including univariate analysis for age distribution, BMI, hallux valgus, and dynamic balance. Bivariate analysis was used to examine the relationship between hallux valgus (independent variable) and dynamic balance (dependent variable) using the chi-square test, with a significance threshold of $p<0.05$.

Results

This study involved a systematic selection process to determine the final sample for analysis. The initial population consisted of 138 individuals assessed based on predefined inclusion and exclusion criteria. Participants who did not meet the inclusion criteria were excluded (n=88), and no participants dropped out (n=0). After the selection process, the final sample comprised 50 participants. Data collection was conducted, and all collected data were successfully analyzed with no missing data (n=0).

The following figure and tables provide a detailed overview of the recruitment process and the results of data analysis in this study. Figure 2 illustrates the recruitment and selection flowchart of research subjects, outlining the steps taken from initial screening to final inclusion. Table 1 presents the frequency distribution of subject characteristics, including demographic and clinical variables. Table 2 displays the statistical analysis of the relationship between hallux valgus and dynamic balance among the study participants.

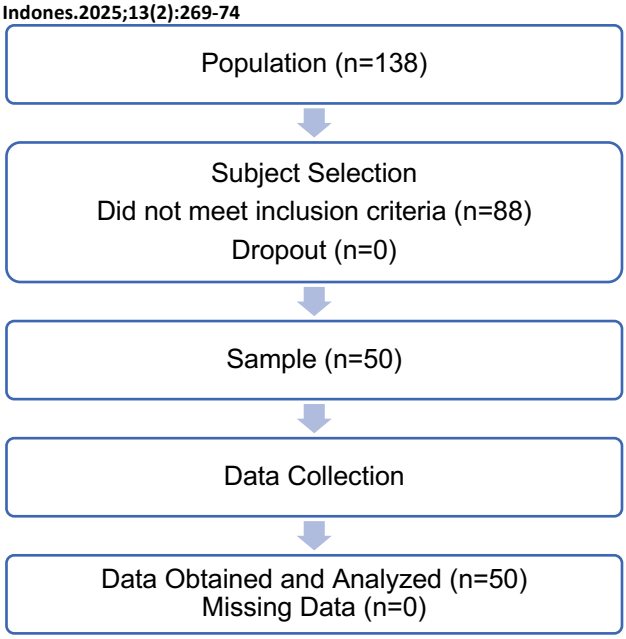

Figure 2. Recruitent and Selection Flowchart of Research Subjects

Table 1. Frequency Distribution of Subject Characteristics

Variable	Frequency (n)	Percentage (%)
Age		
25–31 years	13	26
32–38 years	14	28
39–45 years	9	18
46–52 years	8	16
53–60 years	6	12
Total	50	100
BMI		
Normal	50	100
Total	50	100
Hallux Valgus		
Normal	26	52
HV	24	48
Total	50	100
Dynamic Balance		
Balanced	29	58
Less Balanced	21	42
Total	50	100

Based on Table 1, the most represented age group was 32–38 years (28%), followed by 25–31 years (26%). The 39–45 years group consisted of 9 subjects (18%), while the 46–52 years included eight subjects (16%), and the 53–60 years had the least subjects (6 subjects, 12%). All participants had a normal BMI, confirming uniformity in weight classification across the sample.

Regarding hallux valgus classification, the normal category was slightly more prevalent (26 subjects, 52%) than those with hallux valgus (24 subjects, 48%). Regarding dynamic balance, 29 subjects (58%) were categorized as having good balance, whereas 21 subjects (42%) had poor balance.

Table 2. Relationship Between Hallux Valgus and Dynamic Balance

Hallux Valgus Category	Dynamic Balance		Total (n)	OR (95% CI)	p-value
	Balanced (n/%)	Less Balanced (n/%)			
Normal	22 (84.6%)	4 (15.4%)	26	Reference	<0.001
HV	7 (29.2%)	17 (70.8%)	24	13.36 (3.35–53.20)	
Total	29 (58%)	21 (42%)	50		

The relationship between hallux valgus and dynamic balance was analyzed using the chi-square test, which revealed a significant association ($p < 0.001$). Individuals with hallux valgus were 13.36 times more likely to experience balance impairments than those without hallux valgus (OR = 13.36, 95% CI: 3.35–53.20).

A substantial portion of participants with standard feet exhibited good balance (84.6%), whereas 70.8% of individuals with hallux valgus demonstrated impaired balance. These findings confirm that biomechanical alterations due to Hallux valgus can negatively affect dynamic balance.

Discussion

Subject Characteristics

This study was conducted in Semarapura City, Klungkung Regency, across three schools: SMAN 1 Semarapura, SMAN 2 Semarapura, and SMA Pariwisata Saraswati. A total of 50 participants met the inclusion criteria, with 24 samples from SMAN 1 Semarapura, 15 from SMAN 2 Semarapura, and 11 from SMA Pariwisata Saraswati. This distribution indicates variation in the number of female teachers meeting each school's study criteria.

This study employed a purposive sampling technique, selecting participants based on predefined inclusion and exclusion criteria. One inclusion criterion was a normal BMI to minimize external influences, such as obesity, on dynamic balance.[3] This approach allowed for a more focused analysis of the relationship between hallux valgus (HV) deformity and dynamic balance.

Most study participants were 32–38 (28%), while the least represented group was 53–60 (12%). The 36–45 age group is considered a productive phase when teachers actively engage in teaching and academic duties. Additionally, this period coincides with the peak of a teacher's professional activities, particularly in classroom instruction.[15] Individuals over 40 tend to experience declines in dynamic balance due to muscle and sensory function degeneration.[16] Age distribution provides crucial insights into the relationship between age and dynamic balance in this study, ensuring that observed balance impairments are genuinely attributed to hallux valgus rather than age-related factors.

Among the 50 female teachers studied, 24 individuals (48%) had hallux valgus with a deformity angle of ≥15°, while the remaining 26 (52%) fell within the normal category. As assessed using a goniometer, participants classified as having hallux valgus exhibited metatarsophalangeal I deformity, either unilaterally or bilaterally. The prevalence of hallux valgus in women is 23.74%, higher than in men (11.43%).[17] This condition is often associated with using non-ergonomic footwear and uneven plantar pressure distribution during daily activities.[18] Female teachers face a higher risk of developing HV due to prolonged standing and the frequent use of formal footwear.[19]

Based on the Y-Balance Test results, 58% of participants were classified as balanced, while 42% were categorized as less balanced. The high prevalence of good balance among female teachers may be linked to the predominance of standard feet (52%) over those with hallux valgus (48%). One factor influencing dynamic balance is foot deformity, such as hallux valgus, which can alter the base of support (BOS) and disrupt body stability during movement.[9] Additionally, prolonged standing during teaching sessions may impact teachers' dynamic balance by increasing foot pressure, affecting posture, and reducing stability.[19]

Relationship Between Hallux Valgus and Dynamic Balance

This study found a significant relationship between hallux valgus and dynamic balance among female high school teachers in Semarapura ($p<0.001$). These findings support the initial hypothesis that individuals with hallux valgus exhibit poorer dynamic balance than those with standard feet. A chi-square non-parametric test revealed that individuals with hallux valgus were likelier to be in the less balanced category (70.8%). In contrast, those with standard feet were predominantly balanced (84.6%). The greater the hallux valgus deformity, the worse the individual's dynamic balance.[8] If left untreated, hallux valgus deviations tend to progress over time, further deteriorating dynamic balance with increasing age.[9]

Dynamic balance was measured using the Y-Balance Test (YBT), which was chosen for its ability to assess balance deficits in individuals with musculoskeletal disorders, including hallux valgus.[15] Hallux valgus deformity alters BOS, disrupts plantar pressure distribution, and weakens postural control, affecting movement range in the YBT.[12] Individuals with hallux valgus experience increased loading on the second and third metatarsals and decreased loading on the hallux, impairing mediolateral stability.[20] These disturbances contribute to poorer YBT performance, particularly in the anterior and posterolateral directions.[12]

Biomechanical mechanisms suggest that hallux valgus affects local foot structure and overall postural control, primarily through altered plantar pressure distribution, muscle weakness, and reduced joint flexibility. These findings highlight the importance of addressing hallux valgus deformity, particularly in populations with prolonged standing activities, such as teachers, to prevent further progressive impacts on dynamic balance.

This study aligns with previous research indicating a negative correlation between hallux valgus and postural stability in older adults.[9] Another study reported that individuals with hallux valgus had higher Timed Up and Go (TUG) scores and lower Berg Balance Scale (BBS) scores than the control group, indicating an increased risk of balance impairment.[8] These findings support the association between hallux valgus deformity and decreased stability, particularly in populations with high foot-loading activities.[20] However, these results contrast with studies that found no significant differences in dynamic balance between individuals with and without hallux valgus, potentially due to variations in measurement methods.[10]

This study has several limitations that should be considered. It was conducted exclusively on female high school teachers in Semarapura, limiting the generalizability of findings to a broader population. Additionally, the study did not account for external factors such as footwear type, standing duration, or injury history, which could influence dynamic balance. Moreover, daily footwear choices can impact plantar pressure distribution and gait patterns, warranting further investigation in future studies.

This study provides valuable insights into the impact of hallux valgus on dynamic balance in professions that require prolonged standing. These findings emphasize the importance of early detection and prevention of hallux valgus, mainly through foot ergonomics education and the use of appropriate footwear. Furthermore, physiotherapy interventions, such as hallux flexor strengthening exercises and proprioceptive training, may serve as effective strategies for maintaining dynamic balance. Future longitudinal studies could enhance our understanding of the long-term effects

of Hallux valgus on dynamic balance. Additionally, evaluating pain and disability factors would provide a more comprehensive picture of the functional impact of hallux valgus.

Conclusion

This study found a significant relationship between hallux valgus and dynamic balance among female high school teachers in Semarapura. Chi-square analysis revealed a significant association ($p<0.001$) between hallux valgus and dynamic balance, indicating that individuals with hallux valgus are more susceptible to balance impairments. Hallux valgus deformity, whether unilateral or bilateral, can affect the body's biomechanical mechanisms, including changes in the base of support, postural control, and plantar pressure distribution. As preventive and rehabilitative measures for individuals with hallux valgus, foot muscle strengthening exercises, balance therapy, and biomechanical evaluations can help improve dynamic balance and enhance the quality of life for those affected by hallux valgus.

Author Contribution

I Gusti Ayu Argya Artanti: Conceptualization, methodology, data collection, data analysis, and manuscript drafting.
M. Widnyana: Supervision, guidance on research design, and critical review of the manuscript.
Ni Luh Nopi Andayani: Supervision, validation, and manuscript editing.
Anak Agung Gede Angga Puspa Negara: Supervision, methodological consultation, and final manuscript review.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Udayana (Approval No. 0611/UN14.2.2.VII.14/LT/2024). All participants provided informed consent prior to data collection.

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